



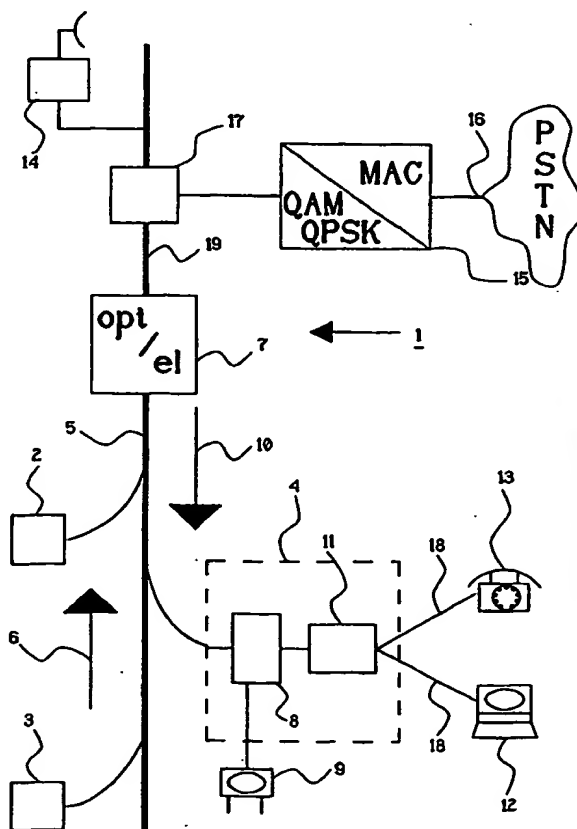
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: A METHOD AND A DEVICE FOR DELAY REDUCTION IN A COMMUNICATION NETWORK

## (57) Abstract

A method and a device for reduction of the total delay of ATM traffic in a communication network where a multitude of nodes (2-4) share a common time multiplex physical medium (5) for transmitting ATM cells in an uplink direction (6). The nodes (2-4) comprise a circuit emulator (11) where the ATM cells which are to be transmitted are packed and a network terminal (8) comprising at least one PLL (27), a phase detector (26) and preferably a phase delay unit (24). The nominal frequency for the allocated time slots on the physical medium (5) is the same as the frequency for generation of the ATM cells. By using the above components the generation of ATM cells will be locked in frequency and phase to the allocated time slots in order to minimize the waiting time in the buffer (26) of the node.



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# A METHOD AND A DEVICE FOR DELAY REDUCTION IN A COMMUNICATION NETWORK

## TECHNICAL FIELD

5 The present invention relates to reduction of a total delay of the traffic in a communication network carrying ATM traffic, wherein a multitude of users share a common physical medium. The reduction is particularly advantageous and useful in the use of so called CBR traffic (Constant Bit Rate) which has a low  
10 tolerance for delay in the network.

## PRIOR ART

In transmission of speech via the telephone network it is important to limit the total delay from transmitter to receiver (round trip delay). If the delay exceeds about 50 ms in for  
15 example a telephone connection an echo canceller is required since the delay then becomes annoying to the persons speaking because about this point the persons start to speak at the same time. When these 50 ms in different standards and specifications were allocated to different local, transit and international,  
20 stations the access network was constituted by a twin cable having no delay. This results in that nowadays when transmission systems, switching and ATM (Asynchronous Transfer Mode) are introduced also in the access network there is no time from the "delay budget" to allocate. This results in tough requirements  
25 regarding a low total delay in the access network.

The reason for the delay in traditional local networks can also be expressed by observing the fact that transport of large data packages and use of a store-and-forward technique in routers and bridges takes time. First there is a delay when the user  
30 accumulates data for filling a whole data package. The same delay effect is repeated every time the package is received by a bridge or a router which has to await the entire package before

it can be transmitted onwards to the next link. The delays vary when the package waits in a queue at links, having a heavy load. If all packages are given the same priority there is no possibility for a time critical package to go past the queue.

Regarding the queue problem, ATM has a priority function which makes it possible for time critical traffic to go past a queue.

Also, a terminal can demand that a certain bandwidth is allocated for a particular channel, which guarantees a required capacity. The system relies on that the traffic is classified as either Constant Bit Rate (CBR) Variable Bit Rate (VBR) or Available Bit Rate (ABR). A terminal which intends to transmit a video or audio sequence via CBR or VBR must reserve the required bandwidth when the connection is set up.

If all traffic has the same priority the problem will of course remain. The problem will be particularly big when a narrow band CBR signal (speech) packed in ATM cells is to be transmitted and when the physical layer only offers a fixed low transmission rate. This is often the case in the uplink direction (the traffic from the users or/and equipment towards a common node, for example a local exchange station or a so called "head end") when PON (Passive Optical Network) and COAX system based on TDM (Time Division Multiplex) are used for transmitting ATM traffic. If the delay also varies over time, this will further add to the total delay at the receiver. The more the delay varies the larger a CDV buffer (Call Delay Variation) will be required.

For example, when a single bus is used by a multitude of nodes for transmitting cells in the uplink direction (from user nodes towards a common node) in a TDM based network, the physical medium, in this case the bus, is a common resource which must be used in the best possible manner. Since only one user at the time can transmit on the bus the cell in the user nodes must

wait for "their turn" before they can be transmitted over the physical medium.

This problem arises within a number of application areas where a multitude of users are to share a time multiplex common physical medium. Closest at hand is speech (telephone) and transmission using a low constant bandwidth over an ATM connection. Another area is cable television. When studying the state of the art it turns out that most documents are found in the technical field of cable television. However, no document shows how one can minimize said delay time.

US 5,546,199 discloses a method for generation (synthesis) of a carriers for the uplink direction in a cable television system by using a reference frequency in the downlink direction. The object is to provide a low-cost carrier having an exact frequency. The carrier is then used in the common medium, in this case a coaxial cable. However, the document does not disclose how one can reduce the total delay in the system. Other documents found, for example US 4,553,161 describes synchronization of uplink data traffic.

#### SUMMARY

The invention shall, using a device and a method in a communication network where a multitude (n) users/nodes share a common physical medium, reduce the total delay in transmission of data package generated at a fixed rate.

The best or simplest would of course be if the connection had a bandwidth which was considerably larger than the need and that there was a function for dynamic bandwidth allocation which immediately generated transmission permission when a data package/cell is ready in one of the nodes. As a difference to this ideal case the bandwidth which is to be shared by several nodes is usually very limited and fully used for payload.

If all traffic has the same priority it will not help to have dynamic allocation of transmission permission. In the case when all nodes simultaneously have a cell ready to transmit the last cell will have to wait a whole period  $T$ , where  $T$  is the time between two cells from a particular connection (the period) when all other nodes must have a transmission permission each during that time.

According to the invention the problem is solved by a device and a method where the generation of ATM cells is synchronized at the users with the generation of uplink time slots on the common physical medium so that a cell is ready to be transmitted in exactly the same moment when it receives a transmission permission. The condition is that an ATM cell can be fitted in a time slot. Hence, it is required that the generation of ATM cells is synchronized at the user nodes with the allocated time slots in the uplink channel. The synchronization can be implemented in a number of ways but the important thing is that the generated ATM cells arrive at the same rate as the time slots on the common physical medium, so that the data packages can be transmitted directly when they have been packed onto said medium without delay. The random phase which is a result between the time slots and the ATM generation in an initial state can be corrected, for example, using a phase delay device and a phase detector or simply by not using a cell and to start the next cell in the correct phase. It is assumed that TDM is used and that in the normal case each connection make use of a fixed "time slots" for transmission of ATM cells. A frame can be defined as  $n$  time slots, one for each connection. A connection uses the "same" time slot in all frames. The period for the frames is constant. It is also possible that the stream of time slots is not defined in frames of the same length but only as a constant flow of time slots. It is however important that the period between two time slots intended for a particular connection is constant.

The advantages which are obtained using this method are clear. The short delay for the packed ATM cells in the user nodes contribute to reduce the total delay in the network.

- 5 It is assumed that the characteristics of the invention defined in the appended claims are new. However the implementation, function and other advantages are best understood using the description and the accompanying drawings.

#### DESCRIPTION OF THE DRAWINGS

- 10 Embodiments of the invention will be described below in conjunction with the accompanying drawings in which:

- figure 1      schematically and simplified shows the uplink traffic in a PON/Coax system having a multitude of nodes and a common physical medium according to the state of the art,
- 15 figure 2      shows a block diagram in an environment where the invention as described below is useful,
- figure 3      shows a block diagram of how a user node is implemented and a method of performing synchronization according to the invention,
- 20 figure 4      shows a block diagram of how a user node is implemented and an additional method of performing synchronization according to the invention.

#### DESCRIPTION OF A PREFERRED EMBODIMENT

- 25 Figure 1 shows the uplink direction for a PON/Coax system having n nodes. The delay in the uplink traffic from n nodes towards a headend according to figure 1 mainly consists of two parts, partly the packing into ATM cells and partly the delay time before the cell can be transmitted.

In order to obtain the correct background and comprehension it can be suitable to use two examples. In the first example dynamic bandwidth allocation is used and in this case some form of MAC function (Medium Access Control) for continuous control and allocation of the available capacity between connections or groups of connections is used. The object is to as soon as possible transmit a cell when it is ready, i.e. to dynamically control the bandwidth allocation. Here we use:

10  $n =$  max number of connections

$t =$  the time to transmit a cell, which depends on the capacity of the connection.

$T =$  the time between 2 cells from a connection (the period), (64 kb/s voice connection results in  $T = 6$  ms).

15 A condition for the capacity of the connection to be enough for all  $n$  connections is thus that  $n \times t \leq T$  or equivalently that  $n \leq T/t$ .

At maximum use of the present bandwidth:  $n = T/t$ .

20 The waiting time varies and the maximum waiting time occurs when all connections have a cell to transmit at the same time (=  $n$  cells). The last cell then will have the maximum waiting time  $T$ . This is however not likely, but the available bandwidth often limits  $n$  to such low values that the probability for a waiting time close to  $T$  is not negligible.

25 If we instead have a static bandwidth allocation, which we have in the invention, consecutive transmission permissions are given to each ATM connection at a fixed time interval  $T_1$  regardless if there is a cell to transmit or not. The method results in a polling at the frequency  $f_1 = 1/T_1$  per connection. A

30 sufficiently high capacity for the connection is obtained when  $T_1 \leq T$ . In order to use the available capacity of the connection



maximally,  $T_1$  is to be chosen as large as possible but not larger than  $T$ . For 64 kb/s speech  $T = 6$  ms. In such a non-synchronized polling method the waiting time has a uniform distribution in the interval  $0 - T_1$ .

The conclusion is that the waiting time varies continuously for the two described methods between 0 and 6 ms. The waiting time can however be controlled as a difference from the packing delay which is fixed and not controllable.

When using the proposed method most of the delay is avoided except for the part which is a result from the packing. The total delay for these parts is therefore reduced to about 6 ms. It should however be noted that any additional delay which can result during transmission or in queues are not taken into account.

The description below mainly concerns transmission of 64 kb/s coded speech, but can also be used for other data rates.

Hence, the conditions are that TDM is used and that in the normal case each connection makes use of a fixed "time slot" for transmission of ATM cells. A frame is defined as  $n$  time slots, one for each connection. A connection uses the "same" time slot in all frames. The period for the frames is constant.

It is also assumed that the uplink and downlink direction on the common medium and the generation of uplink CBR cells (implicitly also the reference frequency for the speech coding, normally 8 kHz) have a common synchronization source.

The waiting time can then be reduced to almost zero if two conditions are fulfilled. Firstly the generation of ATM cells has to be synchronous with the corresponding time slot, i.e. the same number of cells as time slots per time unit. Secondly the ATM cells must be packed and ready for transmission just before

transmission in the allocated time slot. The latter requires that either the time (the phase) when the ATM cell is ready for transmission relative the used time slot can be controlled/  
5 chosen or that a "suitable" free time slot can be allocated to the connection. The latter method should be avoided since it is dependent on other setup connections.

The rate of ATM cells is determined by the AAL being used and by the 8 kHz signal which is normally used for analogue/digital  
10 conversion of a speech signal, i.e. that the nominal frequency/generation of cells is fixed and cannot be controlled. The consequence hereof is that it is the nominal period of time for the allocated time slots that must be adapted to the generation of ATM cells, and not vice versa.

15 Here we describe speech signals and since such high quality standards are put on them that they must be sent by CBR, it is preferably speech signals which benefit from the invention. It is however not restricted to speech signals, but other types of signals having a constant bit rate can of course be transmitted  
20 using the same basic concept of the invention.

When a number of user nodes are to transmit cells towards a common node the term uplink direction is used and when the common node transmits towards the user node the term downlink direction is used. Given that the used time slot in the uplink  
25 channel and the ATM cell generation have the same nominal period of time the ATM cell generation can be synchronized to the uplink channel in the following manner: First the frequency is synchronized, i.e. the period of time for the generated ATM cells is adapted/synchronized to the period of time for the  
30 allocated time slot, giving a random phase between the time slot and the ATM cell generation. Next, the phase is adjusted so that each generated ATM cell becomes ready/packed just in time before it is to be transmitted in "its" time slot, i.e. just before or

at the same time as the time slot is transmitted so that it can be placed in the time slot.

The method implies that regardless of in which node an ATM cell  
5 is generated the phase is adapted to the allocated time slot. The result is that the waiting time can be made arbitrarily short.

Figure 2 shows an example of an environment where the present invention is of great use. The figure shows a HPC (Hybrid-Fiber-Coax)  
10 Coax) cable television system 1 where a multitude of subscribers/nodes 2-4 share a common physical medium, in this case a bus 5. For reasons of simplicity only three nodes are shown but it is to be understood that the number can be much greater.

15 The cable television network is interactive which means that the subscribers can transmit information in the uplink direction 6. This embodiment gives a good example of the use of the invention and is intended to show a practical implementation. In reality the invention can of course be used in all systems with simplex  
20 or duplex communication in a network where a multitude of nodes/subscribers share a common physical medium and where communication with a common unit takes place.

In this example the bus 5 can be a conventional coax cable, but which often in the uplink direction 6 is electrically/optically  
25 converted in a converter 7.

The bus 5 is as mentioned connected to a number of subscribers or nodes 2-4. One node 4 has been enlarged and is shown in the figure in more detail and one can here see an example of how the connection can look like. A network terminal 8 is connected as  
30 an interface towards the bus 5. The network terminal will be described in more detail below. If this is used as a cable television network, a TV 9 is suitably connected as an external

unit for reception of downlink data 10. In order to transmit data in the uplink direction 6, a circuit emulator 11 can be connected to the network terminal 8 according to the figure. The circuit emulator 11 is then e.g. used for packing the data generated by the subscriber in ATM cells. In order to transmit data in the uplink direction 6 the subscriber can use a computer 12 or an ordinary telephone 13 which then is connected to the node 4. The telephone then of course requires an A/D-conversion 29.

The system has an antenna 14 for reception of the TV-signals which then are transmitted to the subscribers. The module 15 illustrates a head-end in a HFC network and provides the telephony function in an interface towards PSTN 16 or the like. The module comprises a MAC (Medium Access Control). In this it is decided which subscriber who is allowed to transmit and when. In the same module 15, modulation of the carrier can also take place. It is common to use a downlink QAM modulation and a QPSK uplink demodulation. The signals from the module 15 and the signals from the antenna 14 can be transmitted on the same medium 19 by means of combining them using a combiner 17.

Figure 3 shows the network terminal 8 and the circuit emulator 11 in more detail. The circuit emulator 11 comprises, besides an ATM cell receiver 20 and a PLL 21 (Phase Locked Loop), also a transmitter 22 where the ATM cells are generated and an A/D converter 29. In this embodiment the A/D converter 29 receives data from a telephone 13 (see figure 2) via the link 18. The emulator 11 is thus connected to the network terminal 8 which in turn has a connection to the bus 5.

When one then without imposing a delay adjusts the phase of the generated digital speech signal so that each generated ATM cell is ready for transmission at an optimal time in order for the waiting time in a buffer 23 in the network terminal 8 is to be minimal, the starting point is always information from a phase

detector 26 at the buffer 23 in the network terminal 8. The detector 26 detects the phase between incoming ATM cells from the transmitter 22 and the allocated time slot on the bus 5. In the circuit according to the solution a signal thus arrives which it takes some time for, let us say  $x$  ms to pack. A transmission permission with downlink data also arrives each  $x$  ms. Thus, the object is to make certain that the generated ATM cell is packed and transmitted to the buffer 23 just before transmission is to take place in the common medium 5, using the phase control of the downlink traffic.

There are many alternative ways to control the phase of the ATM cell generation. The alternative which is illustrated in figure 3 is when the clock in the downlink direction 10 is used as a reference for the uplink traffic 6 as well (here illustrated with the network reference 31). Then the phase in the downlink direction 10 to the circuit emulator 11 can be adjusted using a controllable phase delay unit 24, using the information from the above mentioned phase detector 26 via the connection 28, until the uplink cells obtain a suitable phase (become ready/packed in an optimal time according to above), relative their allocated time slots. This is obtained by means of phase delaying the traffic in the downlink direction in the module 25 in the network terminal 8 so that the PLL 21 in the circuit emulator 11 preferably clocks the A/D converter 29 so that the cells can be packed in the transmitter 22 and that the transmission to the buffer 26 is ready just before the transmission permission arrives for the transmission to the time slot in the common physical medium.

This is called an indirect method since the circuit emulator 11 cannot "see" that the phase changes. It just follows the phase in the downlink direction. This indirect method can also be used in an embodiment where the uplink ATM cells are generated in a unit integrated in the network terminal 8. In this case there is

no need for a separate PLL 21 but the output signal from the phase delay 24 can be used as a clock signal.

5 In another embodiment which is illustrated in figure 4, a control channel 30 can be used for controlling the phase from the PLL 21'. Then one must let the phase detector 26' transmit the same phase control information as above via the control channel 30 to, for example, the PLL 21' from cell generation so that the phase to be controlled to a desired position according  
10 to the above. This method is called a direct method since in this case necessary information is given directly to the PLL 21' of the circuit emulator.

The methods illustrated above are not limited to the shown preferred embodiment but can of course be used in every case  
15 where ATM cells from many sources located at different locations are to be transmitted via a common TDM based physical medium, for example coax, fibre or radio. It should also be noted that the embodiments in figures 3 and 4 only show possible ways to implement the invention as such. The essence of the invention  
20 lies in that one provides control of the generation of ATM cells to a respective allocated time slot in order to minimize the waiting time for the cells.

## CLAIMS

1. A method of reduction of the delay of ATM traffic in a communication network where a multitude of nodes (2-4) which  
5 generate ATM cells use a common time multiplex physical medium (5) for transmission, **characterized in** that the period for the generation of ATM cells in said nodes (2-4) and the time slots of the physical medium are synchronized both with regard to frequency and phase so that the cells in the nodes (2-4) have  
10 been packed at the same time as, or just before, transmission in a respective allocated time slot for a particular node.
2. A method of reduction of the delay of ATM traffic according to claim 1, **characterized in** that the synchronization is obtained by synchronizing the period for the generation of ATM  
15 cells to the period for the allocated time slots on the uplink channel 6 of the common physical medium, by using the clock in the downlink connection 10 as synchronization source also for the uplink direction.
3. A method of reduction of the delay of ATM traffic according  
20 to claim 1 or 2, **characterized in** that the phase when the ATM cells will be ready for transmission relative their respective allocated time slots is identified using a phase detector (26) which senses the phase between incoming ATM cells from a transmitter (22) and the allocated time slot on the bus (5).
- 25 4. A method of reduction of the delay of ATM traffic according to claim 3, **characterized in** that a phase delay unit (24) adjusts the phase of the downlink clock so that the ATM cells generated in the transmitter (22) are packed and transmitted to the buffer (23) so that the waiting time there becomes minimal  
30 before they are transmitted on the common medium (5).
5. A method of reduction of the delay of ATM traffic according to claim 3, **characterized in** that a control channel (3) from the

phase detector (26') transmitting information regarding the phase between ATM cells arriving to the phase detector (26') from a transmitter (22) and an allocated time slot on the bus (5), controls a PLL (21') connected to the transmitter (22) so that the ATM cells generated in the transmitter are packed and transmitted to the buffer (23) so that the waiting time there becomes minimal before they are transmitted on to the common medium (5).

10 6. A method of reduction of delay of ATM traffic in a communication network where a multitude of nodes (2-4) which generate ATM cells use a common time multiplex physical medium (5) for transmission, **characterized in** that the period for generation of ATM cells in said nodes (2-4) is given by the  
15 clock of the downlink direction (10) of the physical medium (5) and that the time slots of the physical medium in the uplink direction (6) is controlled by the same clock, resulting in a random phase between the generation of a cell and the allocated time slots thereof in the uplink direction and that this phase  
20 is adjusted so that each generated ATM cell will be packed at the same time as, or just before it is to be transmitted in the time slot allocated for this particular connection.

7. A device for reduction of the delay of ATM traffic in a communication network comprising a multitude of nodes (2-4) and  
25 a common time multiplex physical medium (5) connected to these, on which medium (5) uplink (6) and downlink (10) traffic is transmitted and the uplink traffic (6) is generated in said nodes (2-4), **characterized in** that the nodes (2-4) comprise at least one network terminal (8) connected to said common physical  
30 medium (5) and at least one module (for example a circuit emulator (11)) where the generation of ATM cells is carried out, wherein the generation is controlled so that the ATM cells are packed and ready to be transmitted at the same time as or just



before transmission in a time slot on the common physical medium (5) allocated for this purpose.

5 8. A device for reduction of delay of ATM traffic in a communication network comprising a multitude of nodes (2-4), according to claim 7, **characterized in** that the nodes comprise means for controlling the phase of when the ATM cell is to be ready for transmission relative the allocated time slot.

10 9. A device for reduction of delay of ATM traffic in a communication network comprising a multitude of nodes (2-4), according to claim 8, **characterized in** that these means comprise at least one phase detector (26) and a phase delay unit (24) which controls the phase for data in the downlink direction in order to control the ATM cell generation in the circuit emulator  
15 (11) so that a cell is packed at the same time as or just before transmission in a time slot allocated for this purpose on the uplink direction of the physical medium.

20 10. A device for reduction of delay of ATM traffic in a communication network comprising a multitude of nodes (2-4), according to claim 8, **characterized in** that these means comprise a phase detector (26') and a control channel (30) from this for transmission of phase information to, a PLL (21') connected to a transmitter (22), for control of the ATM cells generated in the transmitter (22) so that the phase when a cell is packed occurs  
25 at the same time or just before transmission in a time slot allocated for this purpose on the physical medium.

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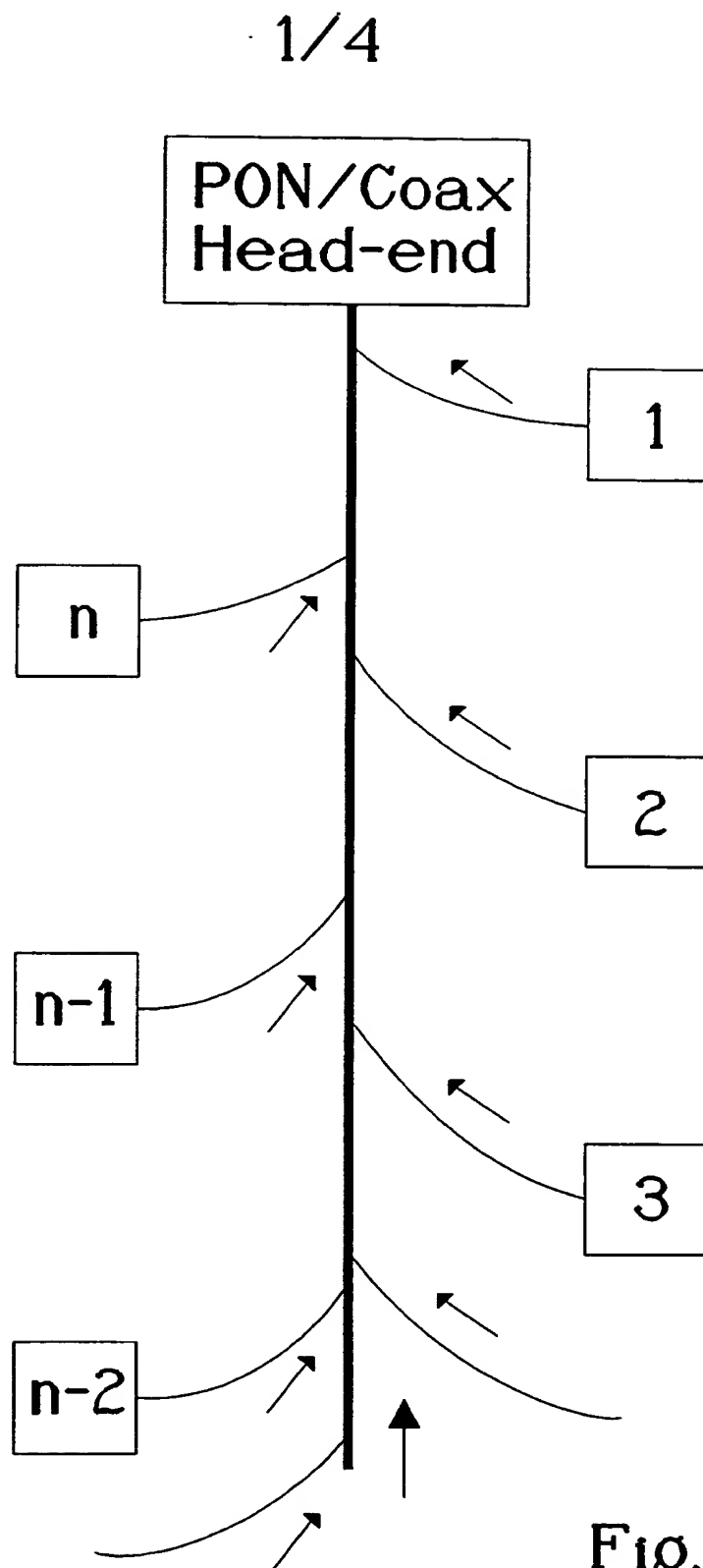
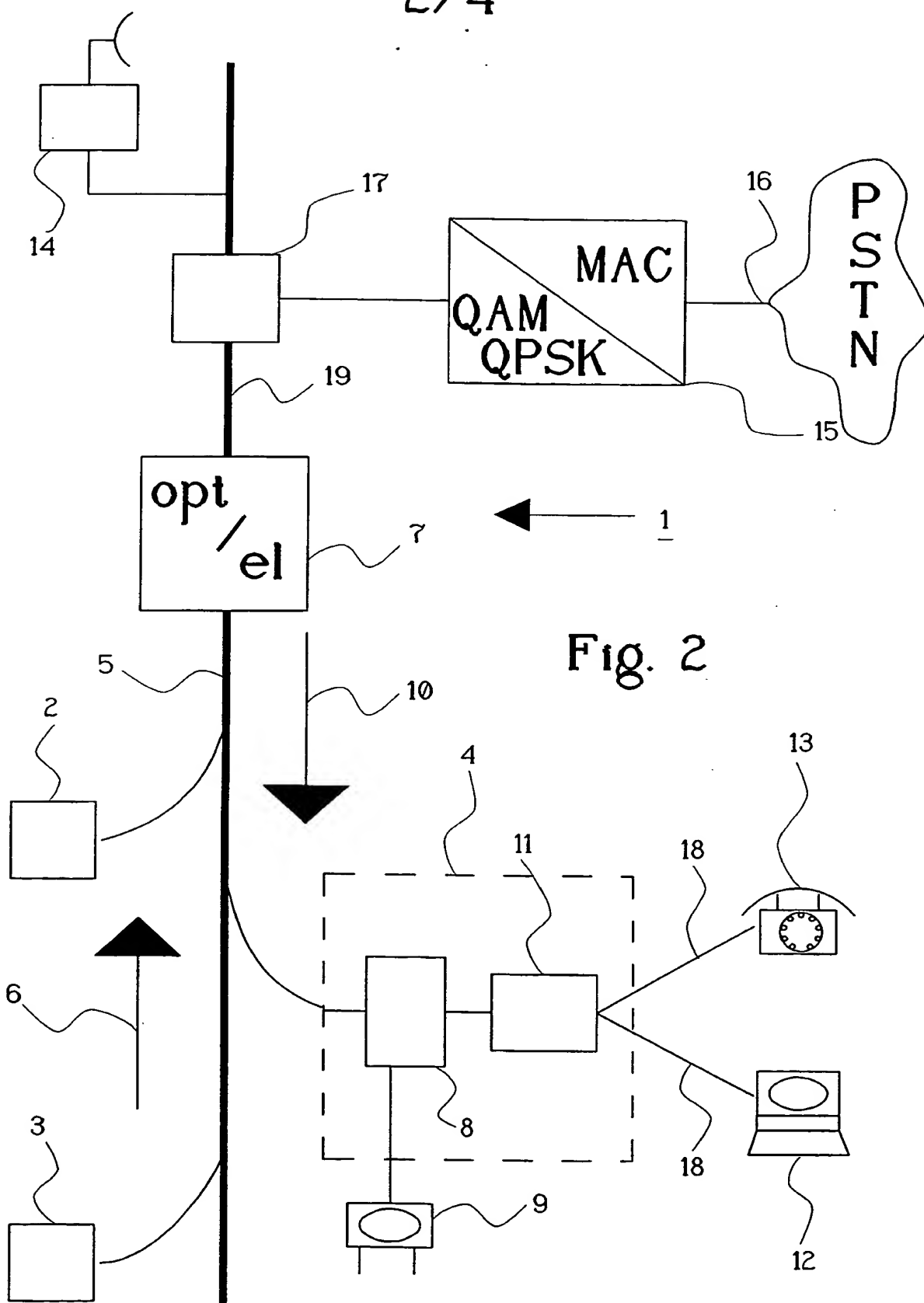


Fig. 1

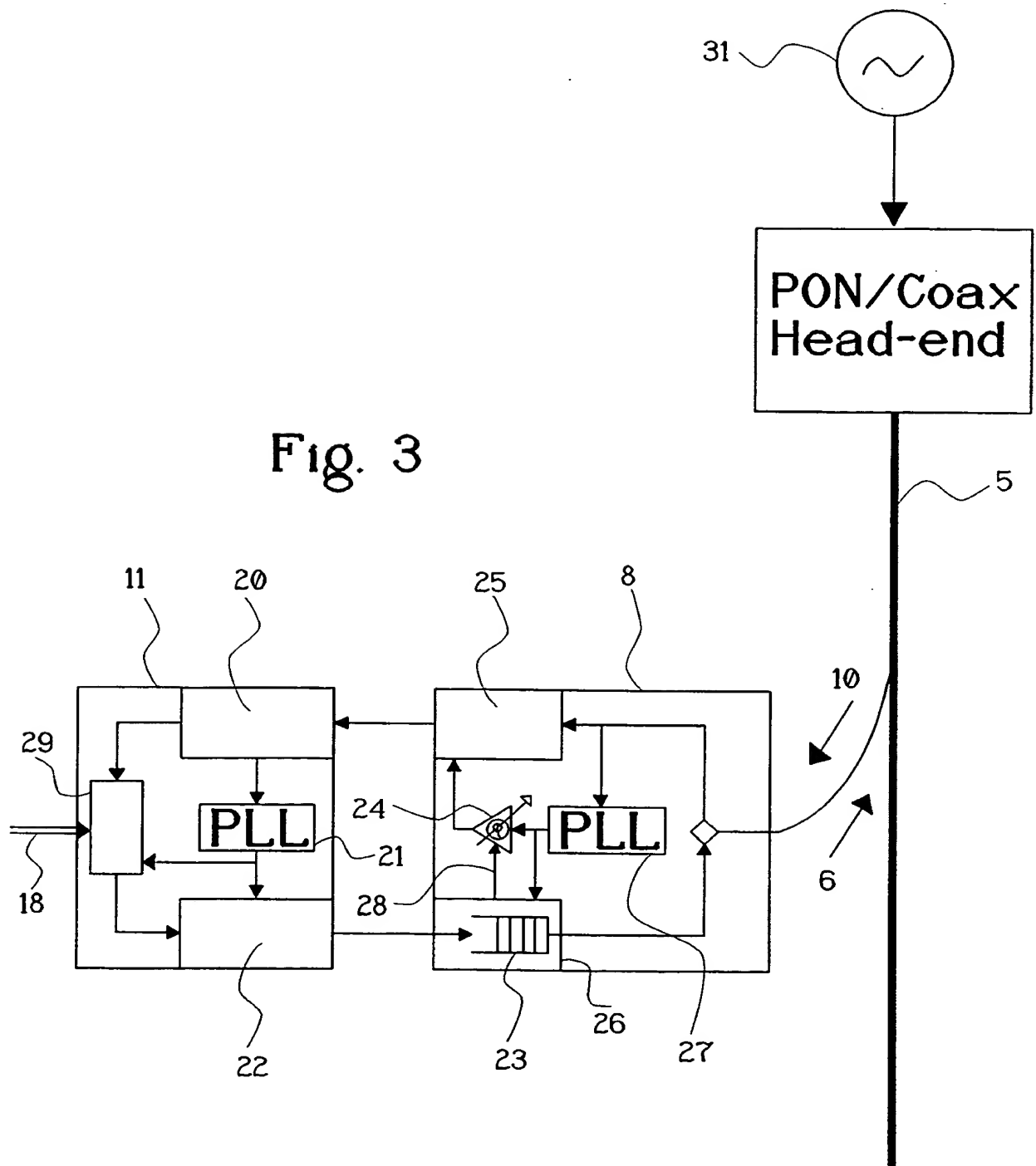
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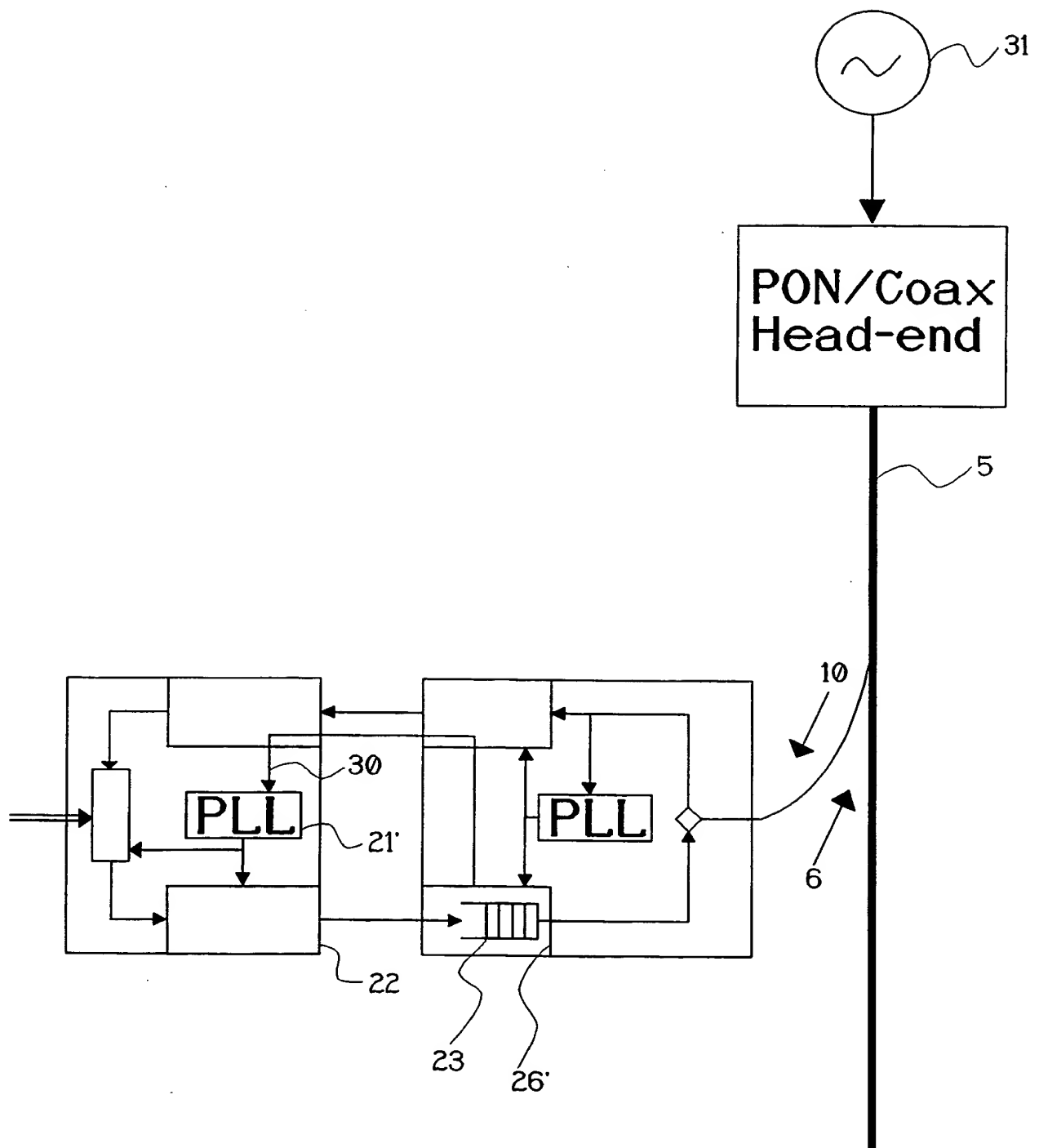


Fig. 4

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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/02219

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 11/04, H04L 12/56

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04L, H04Q, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPIL, EDOC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0768769 A2 (GENERAL INSTRUMENT CORPORATION OF DELAWARE), 16 April 1997 (16.04.97), column 3, line 22 - column 4, line 56; column 12, line 42 - column 15, line 15, figure 4, claims 1-23 --	1-10
A	GB 2310119 A (NORTHERN TELECOM LIMITED), 13 August 1997 (13.08.97), page 7, line 12 - line 24; page 9, line 23 - line 36; page 17, line 11 - page 18, line 2, page 18, line 25 - page 19, line 9, claim 1-18 --	1-10
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☒ Further documents are listed in the continuation of Box C.

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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9703526 A2 (NORTHERN TELECOM LIMITED), 30 January 1997 (30.01.97), claims 1-25, abstract  --	1-10
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